

Claims

[c1] 1. A phosphor blend comprising at least two phosphors selected from the group consisting of (a) $\text{Sr}_2\text{P}_2\text{O}_7:\text{Eu}^{2+}, \text{Mn}^{2+}$; (b) $(\text{Ca}, \text{Sr}, \text{Ba})_a(\text{PO}_4)_3(\text{F}, \text{Cl}, \text{OH}):\text{Eu}^{2+}, \text{Mn}^{2+}$ wherein a is in a range from about 4.5 to and including 5; (c) $3.5\text{MgO} \cdot 0.5\text{MgF}_2\text{GeO}_2:\text{Mn}^{4+}$; (d) $\text{Sr}_4\text{Al}_{14}\text{O}_{25}:\text{Eu}^{2+}$; (e) $(\text{Sr}, \text{Ba}, \text{Ca})_5(\text{PO}_4)_3(\text{Cl}, \text{OH}):\text{Eu}^{2+}$; (f) an europium-activated aluminate phosphor selected from the group consisting of $(\text{Ba}, \text{Ca}, \text{Sr})_2\text{MgAl}_{16}\text{O}_{27}:\text{Eu}^{2+}$, $(\text{Ba}, \text{Ca}, \text{Sr})\text{MgAl}_{10}\text{O}_{17}:\text{Eu}^{2+}$, and $(\text{Ba}, \text{Ca}, \text{Sr})\text{Mg}_3\text{Al}_{14}\text{O}_{25}:\text{Eu}^{2+}$; and (g) an europium and manganese co-activated aluminate phosphor selected from the group consisting of $(\text{Ba}, \text{Ca}, \text{Sr})_2\text{MgAl}_{16}\text{O}_{27}:\text{Eu}^{2+}, \text{Mn}^{2+}$, $(\text{Ba}, \text{Ca}, \text{Sr})\text{MgAl}_{10}\text{O}_{17}:\text{Eu}^{2+}, \text{Mn}^{2+}$, and $(\text{Ba}, \text{Ca}, \text{Sr})\text{Mg}_3\text{Al}_{14}\text{O}_{25}:\text{Eu}^{2+}, \text{Mn}^{2+}$; said phosphor blend being capable of absorbing electromagnetic radiation having wavelengths in a range from about 315 nm to about 480 nm and emitting light having wavelengths in the visible spectrum.

[c2] 2. The phosphor blend of claim 1, wherein said phosphor blend preferably absorbs electromagnetic radiation substantially in a wavelength range from about 350 nm to about 410 nm.

[c3] 3. The phosphor blend of claim 1, wherein a is preferably in a range from about 4.7 to and including 5, and more preferably from about 4.9 to and including 5.

[c4] 4. The phosphor blend of claim 1, wherein said emitted light is white light.

[c5] 5. The phosphor blend of claim 4, wherein said white light has color coordinates substantially on a black body locus of a CIE chromaticity diagram.

[c6] 6. A phosphor blend comprising a mixture of $\text{Sr}_2\text{P}_2\text{O}_7:\text{Eu}^{2+}, \text{Mn}^{2+}$ and at least one phosphor that is selected from the group consisting of (a) $(\text{Ca}, \text{Sr}, \text{Ba})_a(\text{PO}_4)_3(\text{F}, \text{Cl}, \text{OH}):\text{Eu}^{2+}, \text{Mn}^{2+}$ wherein a is in a range from about 4.5 to and including 5; (b) $3.5\text{MgO} \cdot 0.5\text{MgF}_2\text{GeO}_2:\text{Mn}^{4+}$; (c) $\text{Sr}_4\text{Al}_{14}\text{O}_{25}:\text{Eu}^{2+}$; (d) $(\text{Sr}, \text{Ba}, \text{Ca})_5(\text{PO}_4)_3(\text{Cl}, \text{OH}):\text{Eu}^{2+}$; (e) an europium activated aluminate phosphor selected from the group consisting of $(\text{Ba}, \text{Ca}, \text{Sr})_2\text{MgAl}_{16}\text{O}_{27}:\text{Eu}^{2+}$, $(\text{Ba}, \text{Ca}, \text{Sr})\text{MgAl}_{10}\text{O}_{17}:\text{Eu}^{2+}$, and $(\text{Ba}, \text{Ca}, \text{Sr})\text{Mg}_3\text{Al}_{14}\text{O}_{25}:\text{Eu}^{2+}$;

and (f) an europium and manganese co-activated aluminate phosphor selected from the group consisting of $(\text{Ba,Ca,Sr})_2\text{MgAl}_{16}\text{O}_{27}:\text{Eu}^{2+},\text{Mn}^{2+}$, $(\text{Ba,Ca,Sr})\text{MgAl}_{10}\text{O}_{17}:\text{Eu}^{2+},\text{Mn}^{2+}$, and $(\text{Ba,Ca,Sr})\text{Mg}_3\text{Al}_{14}\text{O}_{25}:\text{Eu}^{2+},\text{Mn}^{2+}$; said phosphor blend being capable of absorbing electromagnetic radiation having wavelengths in a range from about 315 nm to about 480 nm and emitting light having wavelengths in the visible spectrum.

[c7] 7.The phosphor blend of claim 6, wherein said phosphor blend preferably absorbs electromagnetic radiation substantially in a wavelength range from about 350 nm to about 410 nm.

[c8] 8.The phosphor blend of claim 5, wherein a is preferably in a range from about 4.7 to and including 5, and more preferably from about 4.9 to and including 5.

[c9] 9.A phosphor blend comprising a mixture of $(\text{Ca,Sr,Ba})_a(\text{PO}_4)_3(\text{F,Cl,OH}):\text{Eu}^{2+},\text{Mn}^{2+}$ wherein a is in a range from about 4.5 to and including 5 and at least one phosphor that is selected from the group consisting of (a) $\text{Sr}_2\text{P}_2\text{O}_7:\text{Eu}^{2+},\text{Mn}^{2+}$; (b) $3.5\text{MgO} \cdot 0.5\text{MgF}_2\text{GeO}_2:\text{Mn}^{4+}$; (c) $\text{Sr}_4\text{Al}_{14}\text{O}_{25}:\text{Eu}^{2+}$; (d) $(\text{Sr,Ba,Ca})_5(\text{PO}_4)_3(\text{Cl,OH}):\text{Eu}^{2+}$; (e) an europium activated aluminate phosphor selected from the group consisting of $(\text{Ba,Ca,Sr})_2\text{MgAl}_{16}\text{O}_{27}:\text{Eu}^{2+}$, $(\text{Ba,Ca,Sr})\text{MgAl}_{10}\text{O}_{17}:\text{Eu}^{2+}$, and $(\text{Ba,Ca,Sr})\text{Mg}_3\text{Al}_{14}\text{O}_{25}:\text{Eu}^{2+},\text{Mn}^{2+}$; and (f) an europium and manganese co-activated aluminate phosphor selected from the group consisting of $(\text{Ba,Ca,Sr})_2\text{MgAl}_{16}\text{O}_{27}:\text{Eu}^{2+},\text{Mn}^{2+}$, $(\text{Ba,Ca,Sr})\text{MgAl}_{10}\text{O}_{17}:\text{Eu}^{2+},\text{Mn}^{2+}$, and $(\text{Ba,Ca,Sr})\text{Mg}_3\text{Al}_{14}\text{O}_{25}:\text{Eu}^{2+},\text{Mn}^{2+}$; said phosphor blend being capable of absorbing electromagnetic radiation having wavelengths in a range from about 315 nm to about 480 nm and emitting light having wavelengths in the visible spectrum.

[c10] 10.The phosphor blend of claim 9, wherein said phosphor blend preferably absorbs electromagnetic radiation substantially in a wavelength range from about 350 nm to about 410 nm.

[c11] 11.The phosphor blend of claim 9, wherein a is preferably in a range from about 4.7 to and including 5, and more preferably from about 4.9 to and including 5.

[c14] 14. The phosphor blend of claim 12, wherein a is preferably in a range from about 4.7 to and including 5, and more preferably from about 4.9 to and including 5.

[c16] 16. The phosphor blend of claim 15, wherein said phosphor blend preferably absorbs electromagnetic radiation substantially in a wavelength range from about 350 nm to about 410 nm.

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having wavelengths in the visible spectrum.

- [c18] 18. The phosphor blend of claim 17, wherein said phosphor blend preferably absorbs electromagnetic radiation substantially in a wavelength range from about 350 nm to about 410 nm.
- [c19] 19. A phosphor blend comprising a mixture of phosphors having a formula of $3.5\text{MgO} \cdot 0.5\text{MgF}_2\text{GeO}_2:\text{Mn}^{4+}$; $(\text{Sr},\text{Ba},\text{Ca})_5(\text{PO}_4)_3(\text{Cl},\text{OH}):\text{Eu}^{2+}$; and an europium and manganese co-activated aluminate phosphor selected from the group consisting of $(\text{Ba},\text{Ca},\text{Sr})_2\text{MgAl}_{16}\text{O}_{27}:\text{Eu}^{2+}$, $(\text{Ba},\text{Ca},\text{Sr})\text{MgAl}_{10}\text{O}_{17}:\text{Eu}^{2+}$, Mn^{2+} , and $(\text{Ba},\text{Ca},\text{Sr})\text{Mg}_3\text{Al}_{14}\text{O}_{25}:\text{Eu}^{2+},\text{Mn}^{2+}$; said phosphor blend being capable of absorbing electromagnetic radiation having wavelengths in a range from about 315 nm to about 480 nm and emitting light having wavelengths in the visible spectrum.
- [c20] 20. The phosphor blend of claim 19, wherein said phosphor blend preferably absorbs electromagnetic radiation substantially in a wavelength range from about 350 nm to about 410 nm.
- [c21] 21. A light source comprising: at least one LED that is capable of emitting electromagnetic radiation having wavelengths in a range from near UV to blue; least one phosphor material selected from the group consisting of (a) $\text{Sr}_2\text{P}_2\text{O}_7:\text{Eu}^{2+},\text{Mn}^{2+}$; (b) $(\text{Ca},\text{Sr},\text{Ba})_a(\text{PO}_4)_3(\text{F},\text{Cl},\text{OH}):\text{Eu}^{2+},\text{Mn}^{2+}$ wherein a is in a range from about 4.5 to and including 5; (c) $3.5\text{MgO} \cdot 0.5\text{MgF}_2\text{GeO}_2:\text{Mn}^{4+}$; (d) $\text{Sr}_4\text{Al}_{14}\text{O}_{25}:\text{Eu}^{2+}$; (e) $(\text{Sr},\text{Ba},\text{Ca})_5(\text{PO}_4)_3(\text{Cl},\text{OH}):\text{Eu}^{2+}$; (f) an europium-activated aluminate phosphor selected from the group consisting of $(\text{Ba},\text{Ca},\text{Sr})_2\text{MgAl}_{16}\text{O}_{27}:\text{Eu}^{2+}$, $(\text{Ba},\text{Ca},\text{Sr})\text{MgAl}_{10}\text{O}_{17}:\text{Eu}^{2+}$, and $(\text{Ba},\text{Ca},\text{Sr})\text{Mg}_3\text{Al}_{14}\text{O}_{25}:\text{Eu}^{2+}$; and (g) an europium and manganese co-activated aluminate phosphor selected from the group consisting of $(\text{Ba},\text{Ca},\text{Sr})_2\text{MgAl}_{16}\text{O}_{27}:\text{Eu}^{2+},\text{Mn}^{2+}$, $(\text{Ba},\text{Ca},\text{Sr})\text{MgAl}_{10}\text{O}_{17}:\text{Eu}^{2+},\text{Mn}^{2+}$, and $(\text{Ba},\text{Ca},\text{Sr})\text{Mg}_3\text{Al}_{14}\text{O}_{25}:\text{Eu}^{2+},\text{Mn}^{2+}$; and (h) mixtures thereof; said phosphor material being capable of absorbing said electromagnetic radiation emitted by said LED and emitting light having wavelengths in the visible spectrum.

27. The light source according to claim 20, wherein said phosphor material further comprises a phosphor selected from the group consisting of (a) $3.5\text{MgO} \cdot 0.5\text{MgF}_2 \cdot \text{GeO}_2 \cdot \text{Mn}^{4+}$; (b) $\text{Sr}_4\text{Al}_{14}\text{O}_{25} \cdot \text{Eu}^{2+}$; (c) an europium-activated aluminate phosphor selected from the group consisting of $(\text{Ba,Ca,Sr})_2\text{MgAl}_{16}\text{O}_{27} \cdot \text{Eu}^{2+}$, Mn^{2+} , $(\text{Ba,Ca,Sr})\text{MgAl}_{10}\text{O}_{17} \cdot \text{Eu}^{2+}$, Mn^{2+} , and $(\text{Ba,Ca,Sr})\text{Mg}_3\text{Al}_{14}\text{O}_{25} \cdot \text{Eu}^{2+}$, Mn^{2+} ; and (d) an europium and manganese co-activated aluminate phosphor selected from the group consisting of $(\text{Ba,Ca,Sr})_2\text{MgAl}_{16}\text{O}_{27} \cdot \text{Eu}^{2+}$, Mn^{2+} , $(\text{Ba,Ca,Sr})\text{MgAl}_{10}\text{O}_{17} \cdot \text{Eu}^{2+}$, Mn^{2+} , and $(\text{Ba,Ca,Sr})\text{Mg}_3\text{Al}_{14}\text{O}_{25} \cdot \text{Eu}^{2+}$, Mn^{2+} .